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Painting walls
Part 2: Failures and remedies

Painting the great majority of wall surfaces presents no special problems and the results are quite successful. Occasionally, however, defects or failures are experienced. This digest discusses the causes of paint failures on interior and exterior wall surfaces and suggests remedial treatments.
It is very often a combination of mildly adverse factors which causes a failure, factors which by themselves may not create problems.

Principal reasons for failure (see also Table 1)

Moisture The original construction water, water gaining access through defects in the structure or water produced by condensation.

Salts and alkali Present in the material of construction or gaining access, for example from rising damp, by deposition as salt spray or occasionally from operations within the building.

Unsuitable surfaces Plaster, rendering or concrete too fresh, friable or contaminated; weathered or deteriorated surfaces or paintwork.

Unsuitable conditions Very high or low temperatures and humidities during application can seriously affect most paints. Dust and dirt produce a 'bitty' finish.

Wrong choice of paint For a particular type of material, existing decoration, or climate. The occasions when the paint itself is not of its normal quality are quite few but some paints are less tolerant than others of adverse factors.

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Technical enquiries arising from this Digest should be directed to Building Research Advisory Service at the above address.

Table 1 Painting walls—typical defects and their prevention

Defect	Cause	Undecorated		Decorated
		To prevent defect	To lessen the risk of defect	To cure after the paint has failed
Loss of adhesion; blistering and flaking of paint	(1) Water behind paint film. Defect associated with alkali attack, efflorescence or friable plaster	Allow wall to dry before decorating. Prevent rain penetration or rising damp	If wall cannot be obtained in a dry condition, use porous alkali-resistant paints	Remedy cause of dampness, strip loose paint, allow to dry and redecorate
	(2) Repeated condensation causing swelling and shrinking of binder (especially found in distempers and fresh paint)	If heavy and repeated condensation cannot be avoided, use other forms of decoration	Hard gloss paints stand limited condensation well when dry. Anti-condensation paints make intermittent *light* condensation inconspicuous. Thermal insulation may help	Remedy for condensation is increased warmth with ventilation
	(3) Powdery or weak surfaces:			
	(*a*) *Dry-out* of gypsum plaster which loses mixing water before it has hydrated. Plaster in severe cases may be powdery or friable on the surface or throughout	Proper treatment of plaster by avoiding too rapid drying in early stages. Modern plasters rarely give trouble	If plaster is not too weak it might take a thin coat of emulsion paint alone or over a lining paper	Strip and replaster
	(*b*) *Delayed expansion*. If plaster suffering from dry-out later becomes wet, it may show slight rippling and softening or extensive rotting, expansion and blistering	As above	As above	As above
	(*c*) *Sweat-out*. If normally set gypsum plaster is wet for long periods, it loses strength	Gypsum plaster unsuitable. Conditions arise from sealing both sides of a new wet wall with impermeable finishes	As above	As above
	(*d*) If plasters, *other than acid Keene's*, are primed following the trowel, a thin powdery layer is formed immediately under the primer	Do not prime plaster *other than acid Keene's* until set and at least surface dry	As above	Surface is so rough it must be replastered
	(*e*) Poor preparation	Clean or strip powdery or dirty surfaces down to sound base	—	Strip, prepare thoroughly and repaint
	(4) Very smooth surfaces, eg glazed tiles	Degrease surfaces and use special primers. Often hard gloss paints without primers or undercoats adhere well	—	Strip and treat as new work
	(5) High suction, overall or in patches, partly due to backgrounds, trowelling and drying conditions. Lightweight plasters liable. So much of the binding medium may be removed that only underbound pigment is left on the surface	Correct choice of plaster and good workmanship. Use an anti-suction or alkali-resisting primer	Special primers; thin coats of emulsion paint; oil-bound distemper thinned with petrifying liquid; use of 'clearcole' or size not advised	Use 'anti-suction' primers over existing paint or after its removal
Cracking of paint	(1) Weathering—with some paints this is their ultimate normal breakdown, eg some hard gloss paints crack and flake rather than chalk or wear away	Repaint while old paint film is firmly held and continuous. Interval between repainting will depend on the paint, its situation and exposure	—	Strip cracked paint and redecorate
	(2) Repeatedly recoating surfaces	—	Emulsion paints are least prone. Where several layers of old oil-bound distemper have been built up and it is desired to avoid stripping, use a binding-down primer. Avoid hard-drying paints and enamel paints	As above

	(3) Application of hard drying gloss over soft undercoat, or application before previous coat has hardened sufficiently; application over contaminated surfaces.	Ensure that finish is used with its own undercoat. Intervals between coats should relate to drying conditions. Do not apply thick coats. Avoid splashes of paste or size on surfaces to be painted	—	Strip and repaint. In some cases rubbing down will remove slight crazing when the work is not affected beneath the surface
	(4) Paint of unsuitable composition even when applied to sound, dry surfaces. Associated with paint which dries hard and shrinks	—	—	Strip and repaint. Consult manufacturer
	(5) Underlying surface shrinking and cracking	Use correct plaster and mortar mixes	Use 'elastic' paints	Use elastic stopper or filler before repainting
Soft sticky films with water blisters and brown or yellow oily runs. Some pigments are bleached or discoloured	Alkali attack on oil paints and oil-bound distempers, by lime in presence of sodium and potassium salts and moisture. Cement products, lime plasters and lime-gauged plasters may cause this. Also caused by residues from alkaline paint removers	Allow to dry before painting. A few weeks subsequent maturing lessens alkalinity. One, or better two, coats of alkali-resistant primer are a useful additional precaution under oil paints. 'Alkali-killing' washes neutralise alkali only in the surface	If decorating before drying is complete, use porous alkali-resistant paints such as emulsion paints. Oil-bound distemper and size-bound distempers satisfactory in mild cases. Alkali-resistant primers lessen risk if impermeable systems (oil-based) must be used	Strip and repaint. Treat as new work
Efflorescence—patchy, crystalline or fluffy deposits sometimes outlining bricks, etc, in the background. (Not to be confused with chalking, a defect of the paint itself.)	Salts from the structure carried to the surface by water and deposited on drying. They may push off the decoration or appear over it	Allow the wall to dry out fully then remove fluffy efflorescence with a dry brush or cloth. Remove residue with a damp cloth frequently wrung out in clean water. Hard bloom needs only sanding or scraping if glossy and offering no key. Avoid water-thinned paints if possible or use them over an alkali-resistant primer if surface is heavily contaminated with salts	If decorating before drying is complete, use thin coats of permeable paints over porous alkali-resistant primers and ensure that drying conditions are good (heat and ventilation). A few emulsion paints offer a better-than-average chance of fluffy efflorescence forming on the surface of the paint without disturbing it	Strip, allow to dry and redecorate, preferably either avoiding water-thinned paints or using them over primers if the surface is heavily contaminated with salts
Coloured spots, patches or stains, often grey, black, purple, red, green or pink (on wall surfaces or paint)	Moulds which are encouraged by damp conditions and can feed on the decoration indoors or outside. Algae need damp conditions but draw little or no food from the paint; usually on exterior especially on weather side. Lichens and moss may develop in time	Remedy damp conditions. Kill organism with a fungicidal wash before painting, allow to dry and remove the organism by scrubbing or scraping	If damp conditions cannot be remedied (eg on external decorations) and there is history of mould on similar buildings, use fungicidal washes and/or fungicidal paints. Less risk with hard-drying and chemically cured paints	In mild attacks the organism may be scrubbed off; otherwise strip off old decoration. Treat the wall with a fungicidal wash. Allow to dry and redecorate with special fungicidal paints
Popping and pitting: craters blown in the surface of the plaster	Expansion of reactive particles in the plaster, usually when wet	—	—	Cut out, make good with plaster. Apply thin coat of primer
Pattern staining: patterns are outlined by variation in thickness of dust deposited on the surface	Affected mainly by surface temperature—pattern often follows variation of thermal capacity or thermal conductivity	Increase insulation to minimise temperature differences	Frequent cleaning or use of darker colours or patterns will make the defects less conspicuous	Improve insulation and repaint
Faint brown or yellow patches, soon after first decoration	Salts and stains from hollow clay tiles, some types of brick (especially if under-fired) and clinker block where a gypsum plaster* and porous paint (eg emulsion) have been used. Highly pigmented emulsion paints especially prone to this defect	Use an 'anti-suction' or alkali-resistant primer with emulsion paints, or impervious (non-emulsion) paint (preferably alkali-resistant)	Use good quality emulsion paints with a slight sheen. (Not very reliable without special primer.) Use a cement-based undercoat to the plaster	Apply (on top of existing paint) an anti-suction or alkali-resisting primer plus further emulsion paint, or flat, eggshell or gloss paint
General patchiness of sheen or colour; mortar joints visible; often occurs after further coats (usually emulsion paint)	Uneven trowelling of plaster*; variable density and suction causing varying penetration of paint binder	As above	As above	As above

*Although reported to be most frequent on lightweight plasters, this is probably only because of the predominance of these plasters in present use.

Moisture

The most important factor for satisfactory painting is the dryness of the wall. Excessive moisture affects the ability to apply most types of paint and affects the long-term performance. It can cause the deterioration of many materials and the movement of salts and promote the growth of moulds. Even in good conditions it may take several months to dry out a new building completely (a rough estimate being one week in drying weather for every 5 mm thickness of wet construction) and dampness often persists during the first year of occupation. Such long periods are usually unacceptable and there is a tendency to apply permanent decoration too soon. The surface of plaster or brickwork may dry quite quickly and can be decorated early provided that some restrictions on the type of decoration are acceptable, principally the inability to produce a glossy finish. Internally, on plaster, a coat of high-permeability emulsion paint is an economical temporary decoration which, unlike distemper, need not be removed later. Internally, ventilation and heat will speed up drying, and dehumidifiers can be used in very bad conditions. Ventilation is particularly important but is very often neglected, undue emphasis being placed on heating. Solid fuel appliances or other heaters vented to the outside will normally produce good ventilation but electric and central heating require extra ventilation by keeping windows open. Portable oil or gas heaters introduce additional water vapour and require maximum ventilation if they are to have any useful effect; without it they aggravate the problem and cause additional condensation on cold surfaces. Completing the painting of buildings on schedule is, of course, easier with dry forms of construction and factory-finished components.

On external work drying cannot be easily accelerated and all that can be done is to protect the surface from further wetting by such means as polyethylene screens arranged to allow ventilation. Rain falling on wet or barely dry paint may cause water spotting and loss of gloss. Even when paint has been applied to a dry or apparently dry surface, moisture may later cause blistering, loss of adhesion and eventual weakening and breakdown on the flim.

Measuring moisture content The condition of the surface is not always a reliable guide to the moisture content of the wall. It is sometimes possible to estimate the suitability for painting from a knowledge of the weather conditions prevailing since the wall was constructed but when in doubt it is much better to measure the moisture content directly. There are several methods available.

Weighing The most accurate method is by direct weighing of the moisture loss during oven-drying of samples obtained by drilling under controlled conditions, using appropriate corrections[1]. A calcium carbide meter can also be used with drilled samples for on-site determinations to avoid heating. The drilling method can determine the moisture at different depths and the presence of soluble salts does not affect the results.

Hygrometer A fairly simple but reliable test is to determine the equilibrium humidity produced in an airspace in contact with the wall, using an accurate hygrometer. The space is best formed by a sealed and insulated box with a hygrometer mounted in the face opposite the wall but a simple alternative (more subject to condensation during temperature change) is to use a sheet of polyethylene fixed to the wall with adhesive tape, with the hygrometer inside. In both methods, several hours, preferably overnight, should be allowed for equilibrium to be reached.
The interpretation of the readings is given in Table 2. Coloured indicator papers which change colour according to the humidity at the surface have also been used in a similar way.

Conductivity meter Two needle probes are forced into the wall and the resistance between them is measured. The resistance is reduced by soluble salts as well as by moisture, so that apparent moisture readings can be misleadingly high and a fairly dry wall may appear unfit to paint. Areas of obvious efflorescence should not be tested. If the wall is believed to be damp but readings at a shallow depth indicate low moisture content, the area should be covered with a sheet of polyethylene and the readings checked again under the sheet next day. If there is woodwork nearby it is very useful to make a check of this; as there is less likelihood of soluble salts, the reading in the wood should be more reliable than in the adjacent plaster, especially if the readings are high in the plaster and low in the wood.

Capacitance meter This has two flat electrodes which are pressed to the surface of the wall. It registers moisture only in the upper 1 or 2 mm and is inaccurate on a rough surface; soluble salts introduce errors.

Microwave meter This projects a beam of high frequency radio waves through the wall to a receiver on the other side which measures the reduction in intensity caused by the presence of moisture. The readings are for the whole thickness of the wall and are affected by the presence of soluble salts. The meter needs access to both sides of the wall, with two operators, and is expensive for infrequent measurements.

Table 2 Wall moisture content with choice of paint for early decoration

Relative humidity in equilibrium with surface %	Wall condition	Electrical meter indication (not microwave meter)	Recommendation	Suitable paint types	
				On alkaline surfaces	On neutral surfaces
100	Moisture visible	Red zone	Preferably postpone decoration and dry further; if treatment essential dry the surface before painting	Cement-based paint; possibly water-thinned epoxy paint; bituminous emulsion paint	Cement-based paint but not on gypsum plaster; possibly water-thinned epoxy paint; bituminous emulsion paint
90–100	Wet or damp patches, no obvious moisture on surface	Red zone	Preferably postpone; painting may be possible but with high risk of failure	As above; possibly emulsion-based paints	As above; emulsion paint internally
90–75	Drying, doubtful visual indication	Amber zone	Decoration possible with limitations and some risk at higher levels of moisture	Some emulsion paints; masonry paints (not chlorinated rubber); possibly epoxy paints	Most emulsion paints (except glossy); masonry paints; plaster primer; flat oil paints
Below 75	Dry	Green zone	No restriction	All oil paints on alkali-resisting primers; chlorinated rubber paint; epoxy and polyurethane paints; some emulsion paints; (alkali-resistance only as a precaution against future dampness)	Oil or emulsion paints (flat, semi-gloss and gloss); masonry paints; epoxy or polyurethane paints, one or two-pack types

Treating moist walls A permeable coating is essential if painting has to be started while appreciable moisture is present. Water-based coatings in general are more readily applicable to slightly moist walls but must not be expected to cope with really wet conditions.

Some water-thinned epoxy based paints are claimed to be applicable to moist surfaces, especially cement, but their permeability when dry is lower than that of emulsion paint; experience of them is limited.

Attempts to hold back excessive dampness by applied coatings are not usually successful, although a number of compositions are claimed to be effective. Their use may be justified if there is an alternative route for moisture to escape to the outside and if the further access of water is unlikely or can be prevented. Metal foils can also be effective sealers if the adhesive is not affected by dampness. But applications of impervious materials to damp patches or to complete walls will usually cause the moisture to reappear elsewhere and if the opposite surface of a solid wall is also impervious, eg tiled, the coating is unlikely to adhere for long. Polyurethane sealers which are claimed to react with the moisture in the wall have been introduced but results with them can be uncertain and they have a very limited capacity for reaction.

Salts and alkali

Many types of brick contain soluble salts which it is impracticable to remove. Salts may be introduced by the use of unwashed sand, especially sea sand, in mortars and plasters, or by the addition of 'frost-proofing' additives to mortar. Rising damp or penetration by sea spray are not likely in new work but may affect redecoration.

Efflorescence is the appearance of these salts at the surface after they have been carried there in solution and the water has evaporated. The salts may be fluffy and easily removed or hard and impossible to scrape or brush off completely. On new work, efflorescence should be allowed to continue, with occasional cleaning off until no more appears. The bulky crystalline type of efflorescence is likely to disrupt impermeable paint films but the very thin, hard films of lime bloom can usually be painted over without such risk if an alkali-resisting primer or a non-saponifiable paint is used. The crystalline type often comes through emulsion paint films without much disruption but it may reduce their adhesion and more may appear with subsequent moisture movement or condensation. A useful treatment for lime bloom (on cement-based surfaces) is the application of a dilute (10 per cent) phosphoric acid solution which converts the lime to an insoluble

compound. Proprietary chemicals to 'neutralise' efflorescence on plasters appear variable in action and not always reliable. Prior application of a thin penetrating coat of plaster primer often prevents further development of crystalline efflorescence. Sea salts are hygroscopic and can cause the appearance of damp patches when humidity is high; small patches may be dealt with by poultices to draw out the salts but large areas may need replastering.

Alkalinity is likely to saponify (ie soften or even liquefy) oil paints and weaken or produce white patches in some emulsion paints. All walls containing lime or cement products should be treated as being liable to cause alkali attack and either non-saponifiable paints or alkali-resistant primers underneath oil paints should be used. The masonry paints based on synthetic rubber or some acrylic solution polymers are fairly resistant and more permeable than oil-based paints used with alkali-resistant primers and can be useful in the early decoration of walls. Chlorinated rubber paints and epoxy resin paints are fully resistant to alkalies in walls but are impermeable. Some pigments are attacked by alkalies and show severe fading but paints likely to be used on cement surfaces are usually formulated with suitable pigments.

Most alkali-resisting primers are based on oils which are not easily saponified; some are based on chlorinated rubber. They vary both in their effectiveness and in their permeability to moisture. In general, the glossier the film the less the permeability; chlorinated rubber paints are least permeable per unit film thickness, and are generally semi-glossy. Because it is difficult to ensure a continuous film without misses or pin-holes, a second coat of alkali-resisting primer is advised where the risk of attack is high. Emulsion paints are usually claimed to be unaffected by alkali, at least as found in wall surfaces, but this is a variable quality and some types may be affected by cement-based surfaces and develop a lime bloom or patchy colour. Even if unaffected themselves by alkali, emulsion paints will not act as a barrier coat under susceptible paints. In general, the exterior types, usually used on cement-based surfaces, are formulated with the more alkali-resistant polymers. It is possible to improve the performance of many emulsion paints on cement rendering by a coat of alkali-resisting primer but this should be thin and penetrate the surface, rather than produce a glossy film to which emulsion paints may not adhere well.

Brown stains with no appreciable surface deposit sometimes appear on emulsion paints and are usually derived from a background of certain types of brick, hollow clay pot or clinkerblock containing soluble salts and coloured materials, or from sands containing organic matter which reacts with alkali. The best defence against this is the use of a cement-based undercoat plaster, preferably air-entrained. A coat of alkali-resisting primer is a further or alternative treatment which may also be used to correct the situation after the stains have appeared. Alternatively, flat oil paints are less susceptible to the defect.

Strong cleaning agents (washing soda, caustic soda, metal phosphates and silicates) or alkaline paint removers should not be used because they can cause saponification if not completely removed and they may be partly absorbed by porous surfaces. Neutral detergents and solvent paint removers are preferable.

Weak or unsuitable surfaces

Unsound, friable surfaces are produced by laitance on cement products or by incorrect hydration of plasters. Surfaces to be painted should be visibly sound and not powdery or crumbling. Excessively dusty and powdery surfaces provide little adhesion for paint films, particularly emulsion paints with their poor penetration, and cause a risk of peeling or flaking as well as a poor 'bitty' finish. New walls should be carefully dusted down before painting. A useful check for unsound surfaces is to apply transparent self-adhesive tape; if it shows little adhesion when pulled off and brings away loose dust and powder, the surface is unlikely to hold paint satisfactorily and should be treated. Most types of paint are affected by mould oil residues on concrete, which should be removed by solvent poultices, emulsion cleaners, neutral detergents or abrasion.

Variable or excessive porosity is often met in all types of plaster and can cause difficult or uneven application and variations in sheen, gloss or colour which persist through several coats of emulsion paint. It can often be overcome by the normal practice of thinning out the first coat with plenty of water and applying the second coat soon afterwards, but sometimes a sealer may be necessary. Alkali-resisting primers are generally suitable, but should be applied thinly so as to penetrate and not leave a glossy film. 'Plaster primers' (which are not necessarily alkali-resistant) can be used on dry, neutral walls. Oil-based paints are less affected by variable porosity, but should in any case be used over an alkali-resistant primer. Minor cracks and imperfections filled with a proprietary powder filler mixed with water may introduce areas of high suction. The difference in porosity may be evened out with a suitable sealer but it is desirable to mix the filler with diluted emulsion paint or with an oil-based undercoat.

Existing paintwork New films shrink on drying and the force exerted may be sufficient to detach existing paint which often has poor adhesion between coats. The adhesion may be tested by cutting through the film with a razor blade in a pattern of 2 mm squares, then firmly pressing

transparent self-adhesive tape to the cut area and pulling it away. Sound paint should show very little detachment; old, brittle paints may break up during the cutting. If the original paint was water-based and not very water-resistant, gentle rubbing with a moist rag or the application of a new paint to a trial area will give some indication of any risk of trouble. Existing gloss paints should be lightly flatted or wet-abraded to ensure good adhesion of subsequent paint.

Areas of flaky paint should be thoroughly cleaned off; it may be found that paint is firmly adhering to other parts of the same wall but this also should be removed if possible because the application of fresh paint often accentuates weaknesses of adhesion. A sealer or binding-down primer is often a useful safeguard but too much reliance should not be placed on its ability to penetrate multiple layers of old paints. Paint films which have cracked deeply but are not flaking should preferably be removed because of the difficulty of obliterating the outline of the cracks. Fine hair-cracking or crazing may sometimes be filled by a knifing stopper or even an undercoat. Slightly blistered or wrinkled paint which has hardened may be left in place after rubbing down to a smooth surface. Sound paint films with a chalking surface should be thoroughly washed down or preferably cleaned with fine wet abrasive paper. Old cement-based paint is often powdery and should be washed down and treated with a penetrating sealer or adhesive primer if it is to be overpainted with a non-cement based coating.

Only a few paints are incompatible with others during application (eg epoxy or chlorinated rubber paints on oil paint) but the adhesion between very different types can be poor and it is always safer to continue the use of any paint of a type which has proved satisfactory. When the nature of the existing paint is not known or a change has to be made to achieve a different decorative effect, or for waterproofing or other reasons, a costly failure may be avoided either by painting a trial patch (which may require considerable time to show any defect) or by submitting a specimen of the existing finish for examination, which the BRE Advisory Service or any consultant would do for a fee.

Mould growth Consistently damp conditions indoors encourage growth of moulds (mildew) which creates an unsatisfactory surface for repainting. Good ventilation rather than fungicidal paints should be the first line of attack, especially at the source of humidity, with, for example, a kitchen fan or extract hood. Removal of mould is often difficult without completely removing the paint as well; it should be scrubbed off as far as possible with a detergent and the surface treated with a fungicidal wash. For a mild outbreak it may be possible to remove the growth and prevent its recurrence by curing the cause without recourse to special paints, but where there is a history of growth or reason to expect it in spite of precautions special paints should be used. A few conventional paints (emulsion or gloss) are available with added fungicides; other manufacturers produce more active paints of different types, particularly for use in breweries, bakeries, etc. There is a risk that the latter will be incompatible not only with existing paint but also with other types that may be used in the future. If there is any likelihood of contamination of foodstuffs or if the paint can be licked by children, paint containing only non-toxic fungicides should be used. Sometimes it may be sufficient to use a paint which is relatively insensitive to water, eg a chlorinated rubber paint or an epoxy resin finish, without any fungicide present, but these should not be applied to existing paints.

Unsuitable conditions during painting

The drying of paints, whether water-thinned or oil-based, is retarded by low temperatures, high humidity and poor ventilation. It is the wall surface rather than the air temperature which is the deciding factor and it should be remembered that the wall surface may be cooler than the air in the morning and during a thaw, when condensation may also be present.

Emulsion paints, including emulsion gloss paints, may show very poor drying properties when the air is cold and damp; below 5°C they may fail to coalesce and thus not form a cohesive film; a rise in temperature after application may be unable to prevent a film failure. High humidity at low temperatures may lead to the paint running and separating on the wall. Paints based on solution polymers (eg chlorinated rubber and synthetic resins without drying oils) are rather better in cold, damp conditions. Oil-based primers, undercoats and gloss paints are usually slow to dry at low temperatures and pick up dirt and grit while they are tacky but will be sound when they eventually harden. Single-pack polyurethane gloss finishes are considerably better in cold, damp conditions than most ordinary (alkyd) gloss paints. Chemically cured finishes are slow to dry at low temperatures and must only be used according to the manufacturer's recommendations.

On porous surfaces in very hot or dry conditions, emulsion paint may be difficult to apply and may powder after drying. In these conditions, prewetting the wall is permissible.

Reference and further reading

1. Improvement of the drilling method for the determination of moisture content in building materials; BRE Current Paper CP22/75.

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